# HR-227 Part II – Nonlinear Finite Element Study of Piles in Integral Abutment Bridges

## Abstract

The highway departments of states which use integral abutments in bridge design were contacted in order to study the extent of integral abutment use in skewed bridges and to survey the different guidelines used for analysis and design of integral abutments in skewed bridges. The variation in design assumptions and pile orientations among the various states in their approach to the use of integral abutments on skewed bridges is discussed. The problems associated with the treatment of the approach slab, backfill, and pile cap, and the reason for using different pile orientations are summarized in the report.

An algorithm based on a state-of-the-art nonlinear finite element procedure previously developed by the authors was modified and used to study the influence of different factors on behavior of piles in integral abutment bridges. An idealized integral abutment was introduced by assuming that the pile is rigidly cast into the pile cap and that the approach slab offers no resistance to lateral thermal expansion. Passive soil and shear resistance of the cap are neglected in design.

A 40-foot H pile (HP 10 x 42) in six typical Iowa soils was analyzed for fully restrained pile head and pinned pile head. According to numerical results, the maximum safe length for fully restrained pile head is one-half the maximum safe length for pinned pile head. If the pile head is partially restrained, the maximum safe length will lie between the two limits.

The numerical results from an investigation of the effect of predrilled oversized holes indicate that if the length of the pre-drilled oversized hole is at least 4 feet below the ground, the vertical load-carrying capacity of the H pile is only reduced by 10 percent for 4 inches of lateral displacement in very stiff clay. With no predrilled oversized hole, the pile failed before the 4-inch lateral displacement was reached. Thus, the maximum safe lengths for integral abutment bridges may be increased by predrilling.

Four different typical Iowa layered soils were selected and used in this investigation. In certain situations, compacted soil (>50 blow count in standard penetration tests) is used as fill on top of natural soil. The numerical results showed that the critical conditions will depend on the length of the compacted soil. If the length of the compacted soil exceeds 4 feet, the failure mechanism for the pile is similar to one in a layer of very stiff clay. That is, the vertical load-carrying capacity of the H pile will be greatly reduced as the specified lateral displacement increases.